ADVAIT MEHLA

Final year undergraduate, Indian Institute of Technology Bombay
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Education

Indian Institute of Technology Bombay *(Nov '20 - present)*

- Major degree (with Honors) : Bachelors of Technology in Engineering Physics - **Grade** : **8.86/10**
- Minor degree : Department of Electrical Engineering

Publications and Posters

- Bala S., Mate S., **Mehla A.** et al. "Prospects of measuring Gamma-ray Burst Polarisation with the Daksha mission" (pre-print). **Accepted** in *Journal of Astronomical Telescopes, Instruments, & Systems* *(2023)*
- Bhalerao V., Sawant D., . . . , **Mehla A.** et al. "Science with the Daksha High Energy Transients Mission" (pre-print). Submitted to *Experimental Astronomy*, under review *(2022)*
- Mate S., Sastry P., **Mehla A.** et al. "Hard X-ray polarisation measurement capability of Daksha", poster presented at *Astrophysical Polarimetry in the Time-Domain Era* held at **Politecnico di Milano, Italy** *(2022)*

Key Projects

Demonstrating Optimal Nonlinear Temperature Control *(May '23 - present)*

Guide : Prof. Rana Adhikari, California Institute of Technology

- Designed and built **low-noise** temperature sensors and PWM driven heater circuits for the control system
- Implemented a **data acquisition** and **actuation** system using a Raspberry Pi and Waveshare AD/DA Board
- Modelled **heat transfer mechanisms** for an insulated mass and fitted experimental data to obtain parameters
- Successfully implemented **PID temperature control** of a mass and achieved simulated performance

Measuring the Polarisation of GRBs with the Daksha mission *(Nov '21 - May '23)*

Guides : Prof. Varun Bhalerao, Dept. of Physics IIT Bombay; Dr. Sujay Mate, TIFR Mumbai

Daksha is a proposed space telescope mission consisting of a pair of satellites to act as a high energy all-sky monitor

- Simulated the interactions of photons with detectors using the **Geant4 toolkit** developed by **CERN**
- Created a **pipeline** to construct **response files** for inferring **source spectra** from the detected counts
- Developed and tested a Python processing pipeline to utilise **Compton polarimetry** with pixellated CdZnTe detectors in order to determine polarisation of sources using a χ^2 **fitting** based **template matching** method
- Estimated the **Minimum Detectable Polarisation** of the mission through a **novel Monte Carlo** method

All-sky, sub-MeV Compton Imaging with Daksha | *Undergraduate Thesis* *(Aug '23 - present)*

Guide : Prof. Gulab Dewangan, Inter-University Centre for Astronomy and Astrophysics

- Integrated **NaI scintillators** into the Daksha **mass model** and simulated **SiPM readout** to generate realistic data including **Poisson timing information** and effects of **spatial and energy resolution**
- Implemented a **Compton reconstruction** algorithm to utilise coincident events between **multiple NaI and CdZnTe detector pairs** to effectively localise sources in the sky and project them with **HealPy**

Resonant Mass GW Detectors : Instrumentation & Noise Sources | *Report* *(Autumn '22)*

Course Project, PH821: Gravitational Wave Astronomy and Physics, Prof. Archana Pai, Department of Physics

- Surveyed literature on resonant bar gravitational wave detectors and the measurement challenges associated
- Analysed the **electro-mechanical oscillator** system and its transfer function to understand its advantages
- Quantified the **minimal detectable energy** and **noise spectral density** of the dominant noise sources

Studying an Exoplanetary System with GROWTH-India Telescope | *Report* *(Spring '23)*

Course Project, PH556: Observational Astrophysics, Prof. Varun Bhalerao, Department of Physics

The GROWTH-India Telescope is a 0.7m robotic transient telescope located at the Indian Astronomical Observatory

- Submitted a **proposal** to take continuous observations of a **transit of WASP-43b** around its host star
- **Reduced images** to compute the evolution of relative flux during the transit using `Astropy` and `Photutils`
- Fitted the observed transit data to a model using **Markov-Chain Monte Carlo** method with the `exoplanet` package and **inferred** the planetary radius, impact parameter and mid-transit time **within** 1σ of actual values

Academic Achievements

- Among the **top 23** students worldwide to be awarded a fully-funded **LIGO-SURF** internship at Caltech *('23)*
- Bestowed the **Undergraduate Research Award** for performing **exemplary research** by IIT Bombay *('23)*
- Awarded a **Branch Change** to **Engineering Physics** based on exemplary academic performance *('21)*
- Secured a percentile of **99.923** among over **1 million** candidates in **JEE Mains** *('20)*
- Awarded the prestigious **Kishore Vaigyanik Protsahan Yojana (KVPY) Fellowship** by the Department of Science and Technology, Government of India **twice** with **All India Ranks 306** and **466** *('19,'18)*
- Among the **top 450** students nationally selected for **Indian National Physics Olympiad (INPhO)** *('19)*

Workshops

Radio Astronomy Winter School | *NCRA - TIFR* *(Dec '22)*

Ten-day offline school consisting of talks and experiments on the fundamentals of radio astronomy

- Attended seminars by renowned experts on topics like radiative processes, techniques and instruments used in radio astronomy, observational radio astronomy, cosmology and fast radio bursts
- Recorded observations of **HI emissions** at different longitudes in the **galactic plane** with a rudimentary horn antenna and processed the data to generate a **rotation curve** for the Milky Way

GEANT4 and its Application to High-Energy Physics and Astrophysics | *IUCAA* *(Dec '22)*

Five-day offline workshop on the applications of GEANT4 for astrophysics and high energy physics instruments

- Attended talks by prominent researchers working on various experiments and missions like CMS, Hyper-K, POLAR, Fermi, Swift and AstroSat and learnt about the instruments and simulation techniques utilised
- Implemented detector systems like **CMS-HGCAL** and a **scattering polarimeter** in **Geant4** from scratch during hands-on tutorial sessions and analysed resulting data using Python and ROOT

Other Projects

Team Member, GLEE | **IIT Bombay Student Satellite Program** *(May '21 - June '22)*

A 70+ member student team with the vision of making IIT Bombay a centre of excellence in space technology

- **Instrumentation Subsystem**
  - Scrutinised components & constructed a multi-stage **readout circuit** for a PIN diode based **spectroscope**
  - Tested and verified the functioning of the circuit by injecting input signals and analysing the output waveforms
- **Communications Subsystem**
  - Designed several iterations of a 4cm x 4cm **prototype ChipSat** capable of processing and **wirelessly transmitting** data from the **lunar environment** gathered by **two sensors** interfaced with a microcontroller
  - Learnt **embedded C** and implemented **UART**, **SPI** communication protocols to achieve data transmission

Truly Random Number Generator using Chaos *(Autumn '22)*

Course Project, PH435: Microprocessors Lab, Prof. Pradeep Sarin, Department of Physics

- Designed, simulated and constructed a chaotic **Chua circuit** tuned to operate in the double scroll region
- Interfaced the circuit with an Arduino and pre-processed the bitstream using the **von Neumann whitening** algorithm to de-skew the incoming random bits and subjected them to rigorous tests of randomness

Closed Loop Analog LED Controller *(Autumn '21)*

Course Project, PH 233 : Op-amp Circuits Lab, Prof. Pradeep Sarin, Department of Physics

- Designed a **P-Type Controller** that regulates the intensity of an LED in accordance to external noise
- Debugged and tuned the circuit parameters after implementing it on a breadboard using operational amplifiers

Simulating Kirkwood Gaps *(July '21 - Sept '21)*

Krittika, the Astronomy Club of IIT-B (Summer Project)

- Implemented a **Monte Carlo simulation** to evolve large distributions of asteroids over millions of years
- Observed the emergence of **Kirkwood gaps** in the **asteroid belt** along with features like the Jupiter Trojans
- Optimised simulation times by a factor of **6 to 12** via implementation of **parallelised code** and utilisation of **high performance computing** libraries like **OpenMP** and **CUDA Fortran**

Analysis of the Nonlinear Dynamics of Neuronal Models *(Autumn '21)*

Course Project, PH567: Nonlinear Dynamics and Chaos, Prof. Amitabha Nandi, Department of Physics

- Designed and constructed an **analog circuit** to mimic the Nagumo **neuronal model** and demonstrated the **action potential** and other **neuronal behaviour** by visualising signals on a digital oscilloscope
- Explored the **phase space** of the **Fitzhugh model** by numerically integrating the dynamical equations

Leadership Experience

Manager | *Krittika, the Astronomy Club of IIT Bombay* *(June '22 - May '23)*

Lead a team of 8 to organise outreach and research activities to propagate astronomy at IITB and beyond

- Handled a budget of **INR 250k+** used to purchase telescopes and organise events for the student body
- Acquired approval for the development of the **IIT Bombay Observatory** with funding of **INR 1.8 million**
- Organized the **Krittika Summer Projects**, an **8-week** long program aimed at exposing students to astronomical research & received **100+ applications** along with **international participation** for the first time
- Hosted regular observing sessions for special astronomical events with a reach of **1000+** students and staff

Technical Skills

Languages	C/C++, Python, Fortran, MATLAB, LaTeX
Packages/Libraries	Astropy, HealPy NumPy, Matplotlib, SciPy, SymPy, Pandas, Numba, OpenMP, CUDA
Other Software	Geant4, Git, LTspice, Photoshop, EAGLE, Arduino

Teaching

Teaching Assistant, PH 111: Introduction to Classical Physics *(Spring '23)*

- Selected for the position of a Teaching Assistant responsible for conduction regular tutorials for a class of **40 students**, guiding them with coursework and solving conceptual doubts
- Ensured smooth conduction of course by acting as a point of contact between students and the course instructors, graded assignments and exams and provided feedback to students

Teaching Assistant, PH 435: Microcontroller Lab *(Autumn '23)*

- Responsible for grading and assisting groups of **15+ students** during weekly Arduino electronics lab sessions
- Mentoring groups of students with their hardware projects and guiding them with debugging and troubleshooting

Key Courses

Physics	Observational Astrophysics, Advanced Astrophysics*, Gravitational Wave Astronomy, General Relativity, Quantum Mechanics I & II, Classical Mechanics, Nonlinear Dynamics Thermal Physics, Electrodynamics, Introduction to Nuclear & Particle Physics
Mathematics	Differential Calculus, Integral Calculus, Linear Algebra, Complex Analysis, Differential Equations I, Differential Equations II, Numerical Analysis
Electronics	Basic Circuits Lab, Op Amp Circuits Lab, Digital Electronics Lab, Microprocessors Lab, Digital Systems, Electronic Devices, Signal Processing, Image Processing, Machine Learning

Extracurricular Activities and Interests

- Captured several images of **deep sky objects**, **Milky Way** and **planets** along with special astronomical events like **comets, eclipses and meteor showers** with a basic DSLR, lenses and equatorial mount
- Skilled in processing raw data from professional telescopes like the **Hubble Space Telescope**, and awarded NASA Astronomy Picture of the Day for processing an image of the **Trifid Nebula** in 2022
- Featured multiple times on social media outreach pages of **NASA** and **ESA** for astrophotography
- Awarded a **cash prize** and an **internship offer** as **sole winner** out of **20+** teams in the **Astronomy General Championship** conducted by Nayam Innovations and Institute Technical Council, IITB *('22)*
- Attended the 3-day **Vijyoshi National Science Camp** conducted at **IISc Bangalore** for facilitating interactions between KVPY Fellows and world-renowned researchers from various fields of science *('19)*